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The Geochemistry and Geochronology of Cassiterite from the New England Fold Belt, NSW

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The Project:

- Can **cassiterite** be used to **characterize hydrothermal systems** in a way similar to zircon?

- A case study from the tin mineralized **Mole Granite in the New England Fold Belt**, NSW.

- Geochemistry
  - Oxygen isotopes
  - Trace elements

- Geochronology
  - U/Pb dating

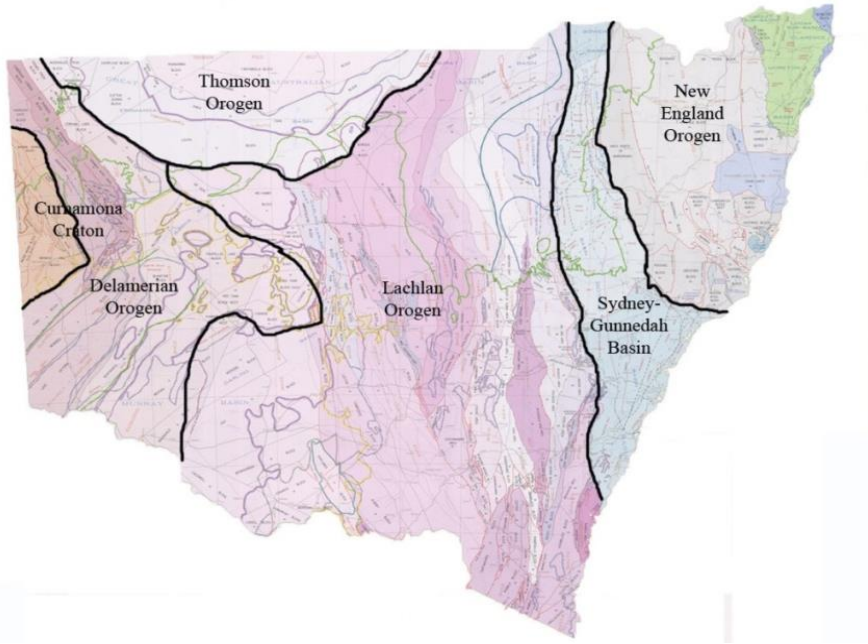
Cassiterite

- SnO_2 contains 78.77 wt. % tin.
- Tin is used in solder, as tin plate to prevent rusting.
- Typically formed in Ilmenite series granites.
- Reduced fluids facilitate the movement of Sn^{4+} as a chloride complex.
- Australia one of the world's largest tin producers in the 80's.

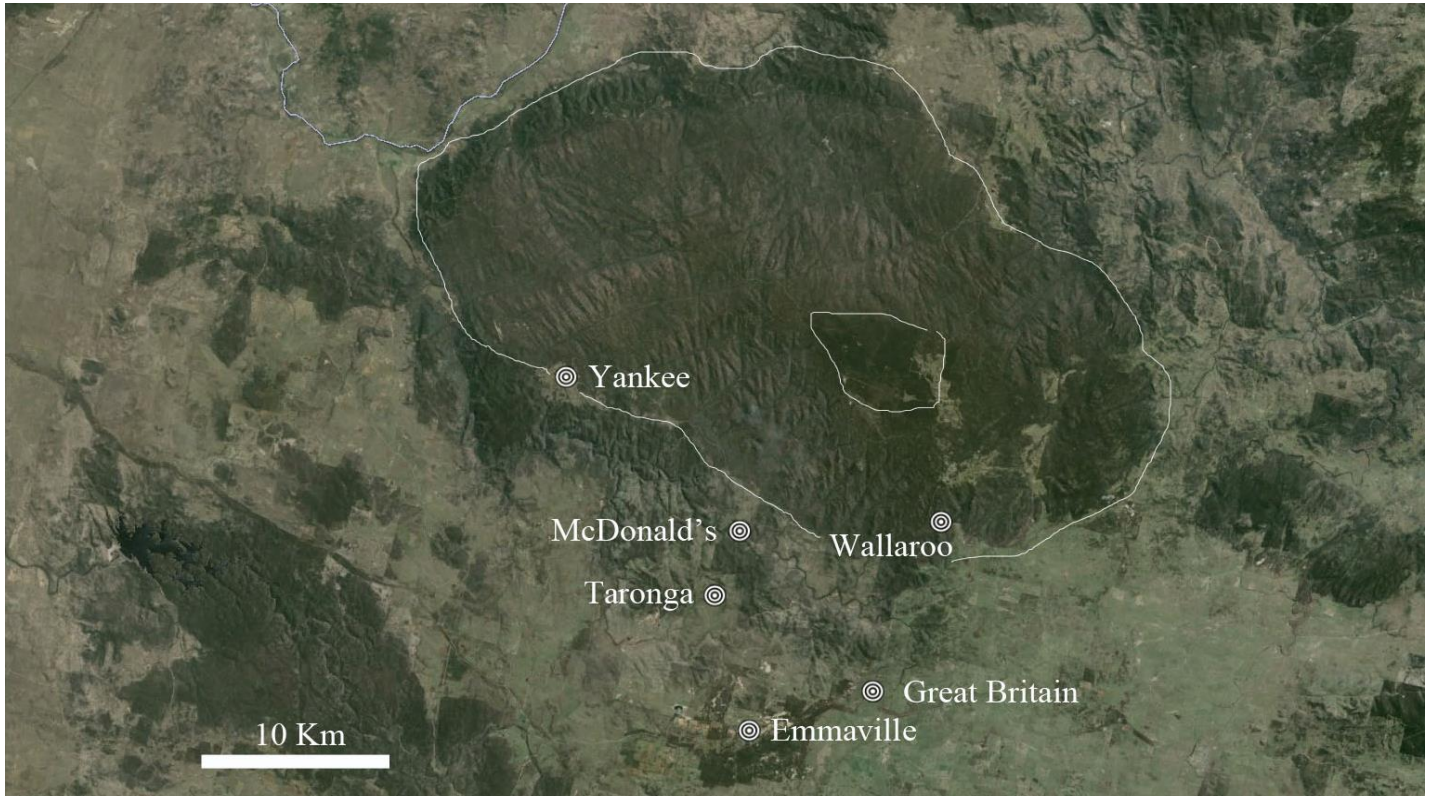
Aims

- Characterize the timeframe of cassiterite mineralization
- Determine the oxygen isotopic variation
- Determine the trace element pattern variation of cassiterites
- Characterize zonation and alteration intragranularly
- Assess the Yankee cassiterite

Sample Locations



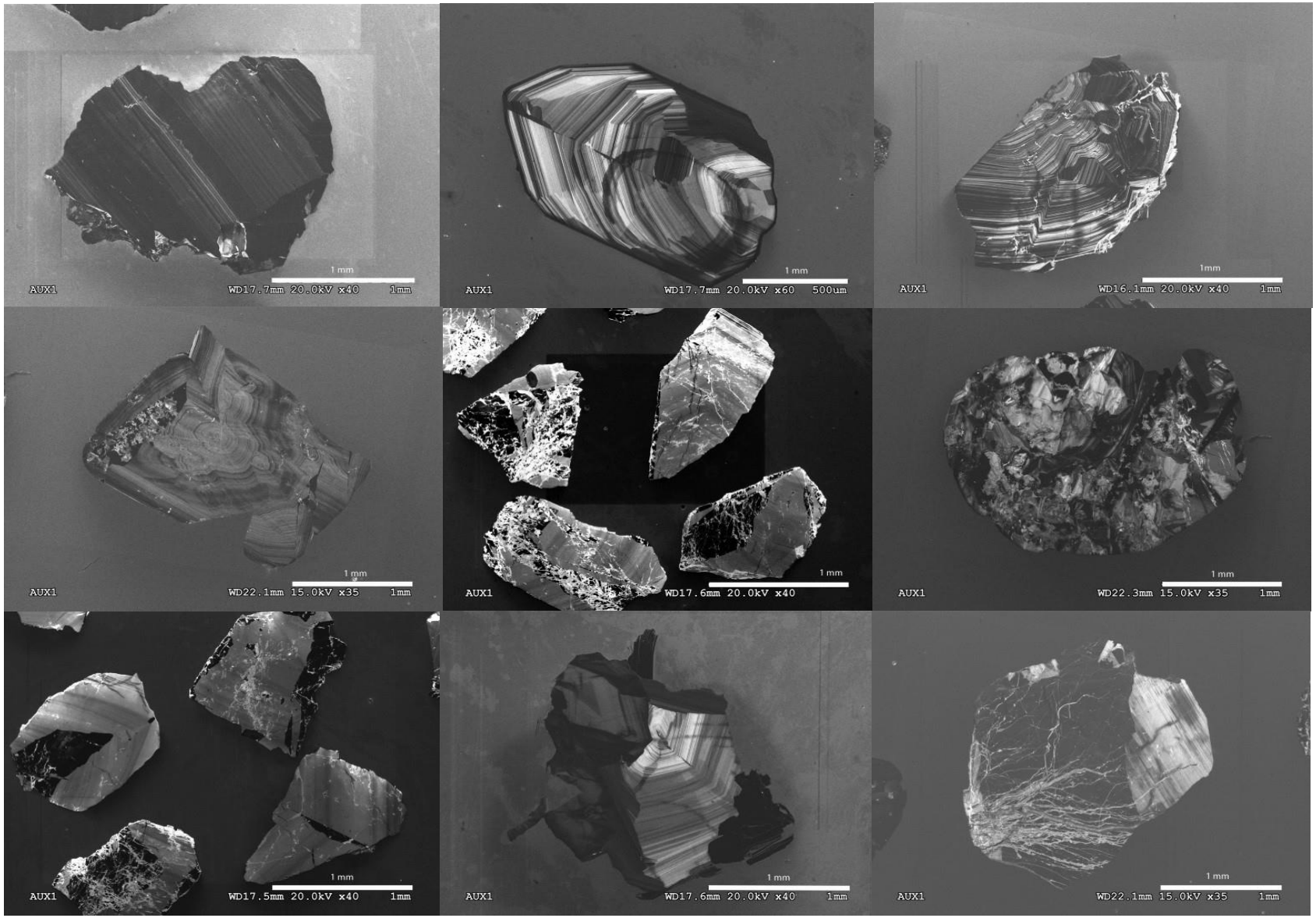
The Mole Granite

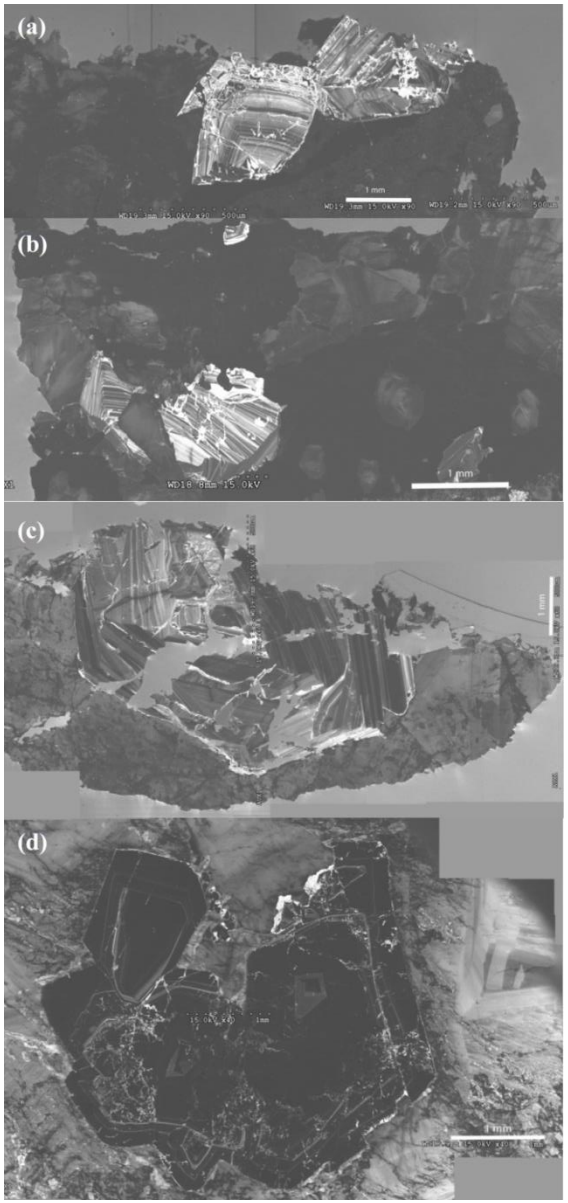


Analytical Methods

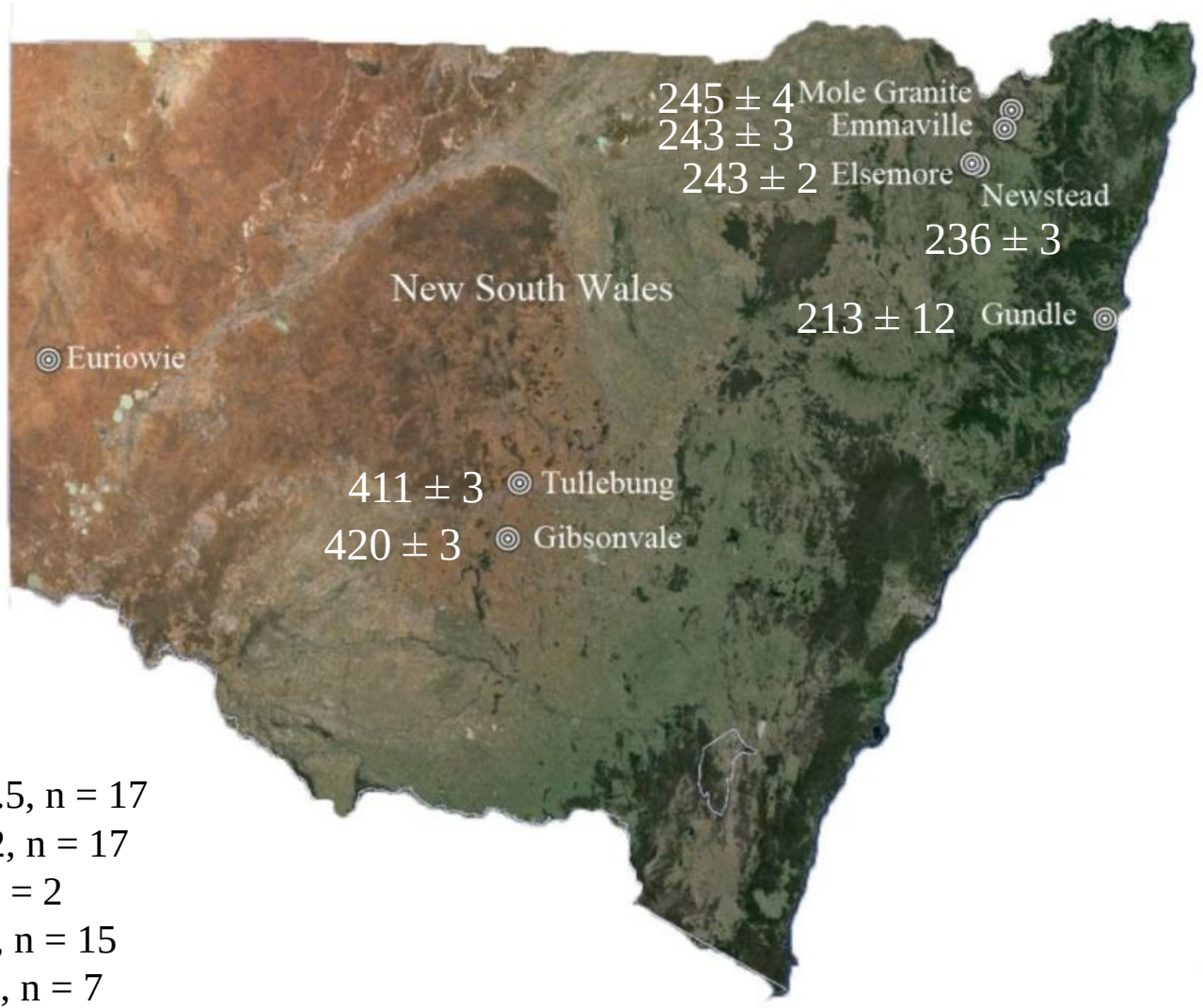
- SEM-Cathodoluminescence
- Laser Ablation-ICP-MS
  - $^{238}U/^{206}Pb$ dating
  - Trace elements
- SHRIMP SI
  - Oxygen isotopes

Results: SEM CL Imaging

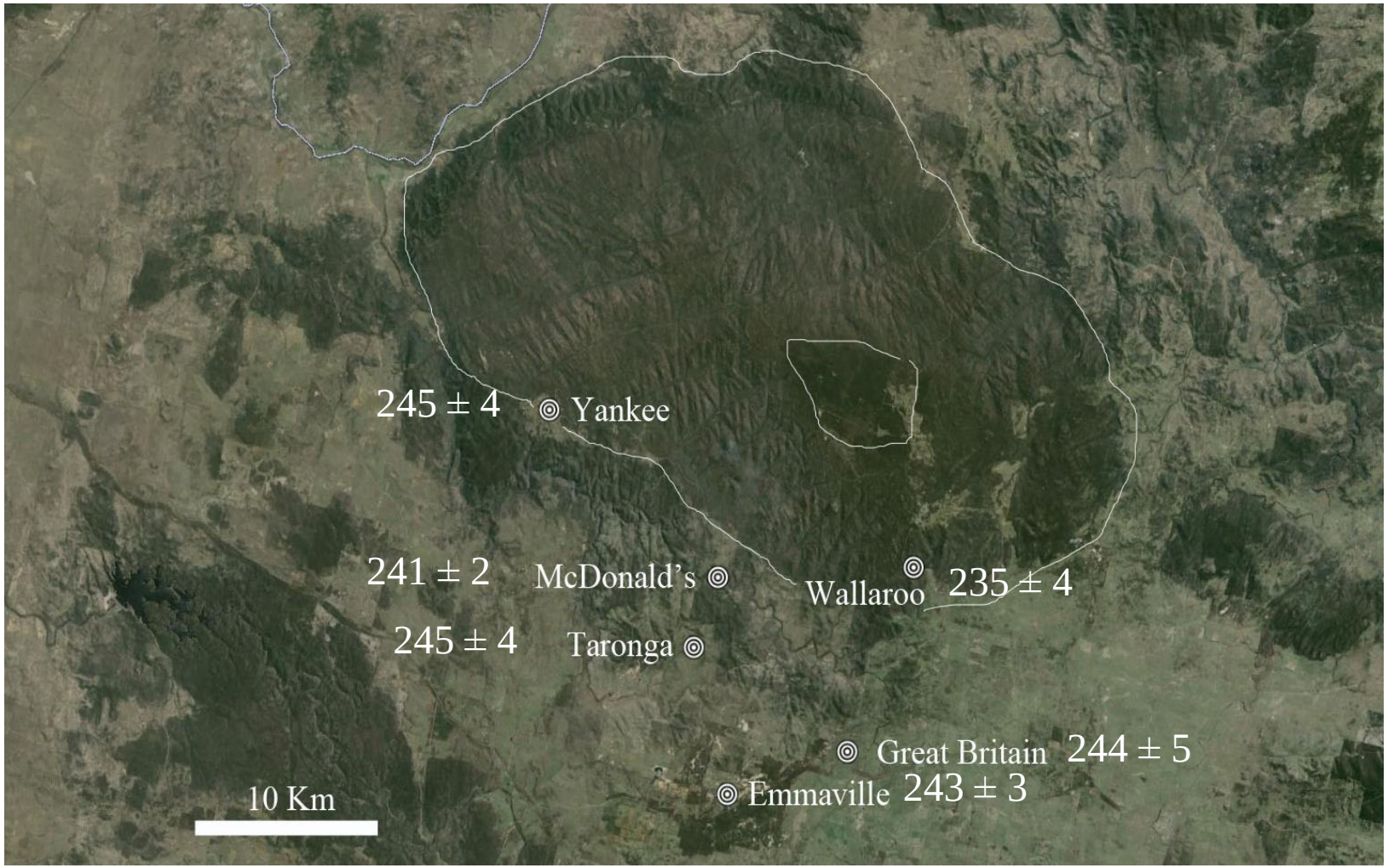

AUX1 WD17.7mm 20.0kV x40 1mm
AUX1 WD17.7mm 20.0kV x60 500um
AUX1 WD16.1mm 20.0kV x40 1mm
AUX1 WD22.1mm 15.0kV x35 1mm
AUX1 WD17.6mm 20.0kV x40
AUX1 WD22.3mm 15.0kV x35 1mm
AUX1 WD17.5mm 20.0kV x40 1mm
AUX1 WD17.6mm 20.0kV x40 1mm
AUX1 WD22.1mm 15.0kV x35 1mm


(a)
1 mm
(b)
1 mm
(c)
(d)
1mm

Results: U/Pb Dating

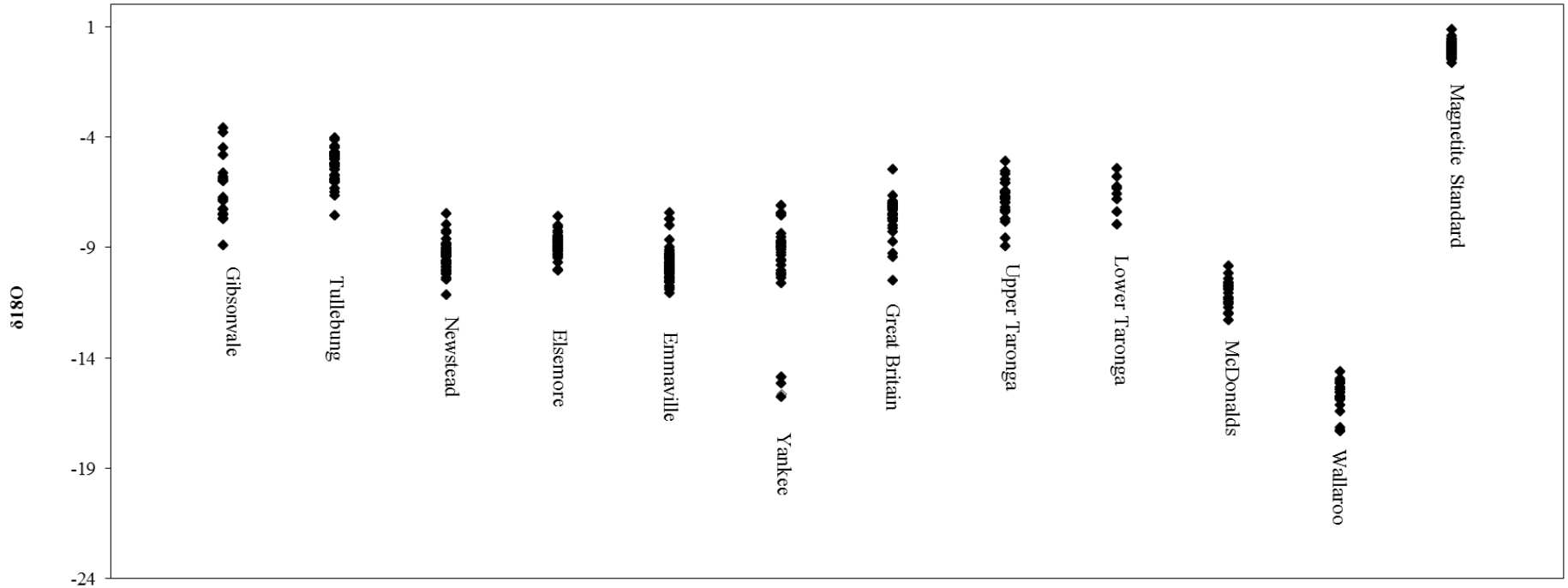


- Gibsonvale: MSWD = 1.5, n = 17
- Tullebung: MSWD = 2.2, n = 17
- Gundle: MSWD = 0.1, n = 2
- Elsemore: MSWD = 1.1, n = 15
- Newstead: MSWD = 0.6, n = 7
- Emmaville: MSWD = 1.3, n = 27
- The Mole Granite (based on Taronga): MSWD = 1.6, n = 8

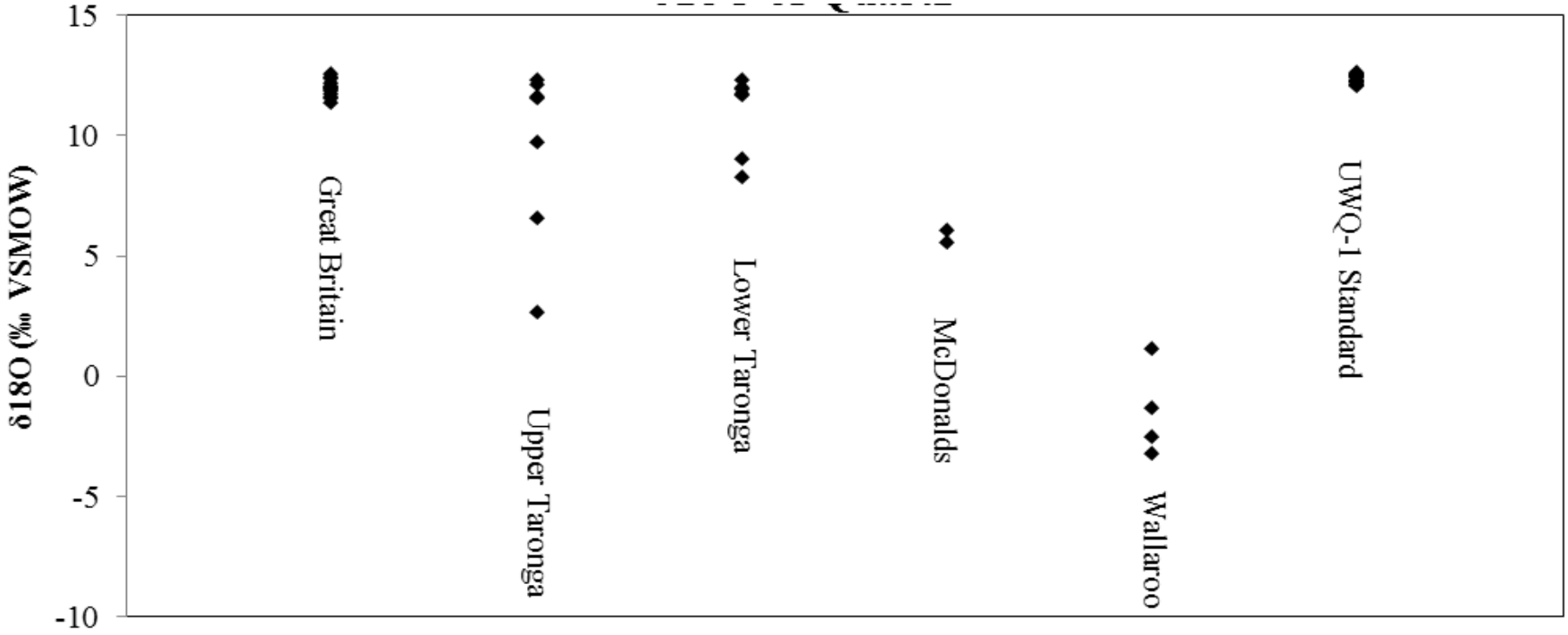

245 ± 4
Yankee
241 ± 2
McDonald's
Wallaroo
235 ± 4
245 ± 4
Taronga
Great Britain
244 ± 5
Emmaville
243 ± 3
10 Km

Results: Oxygen Isotopes

δ18O of cassiterite



δ18O of quartz

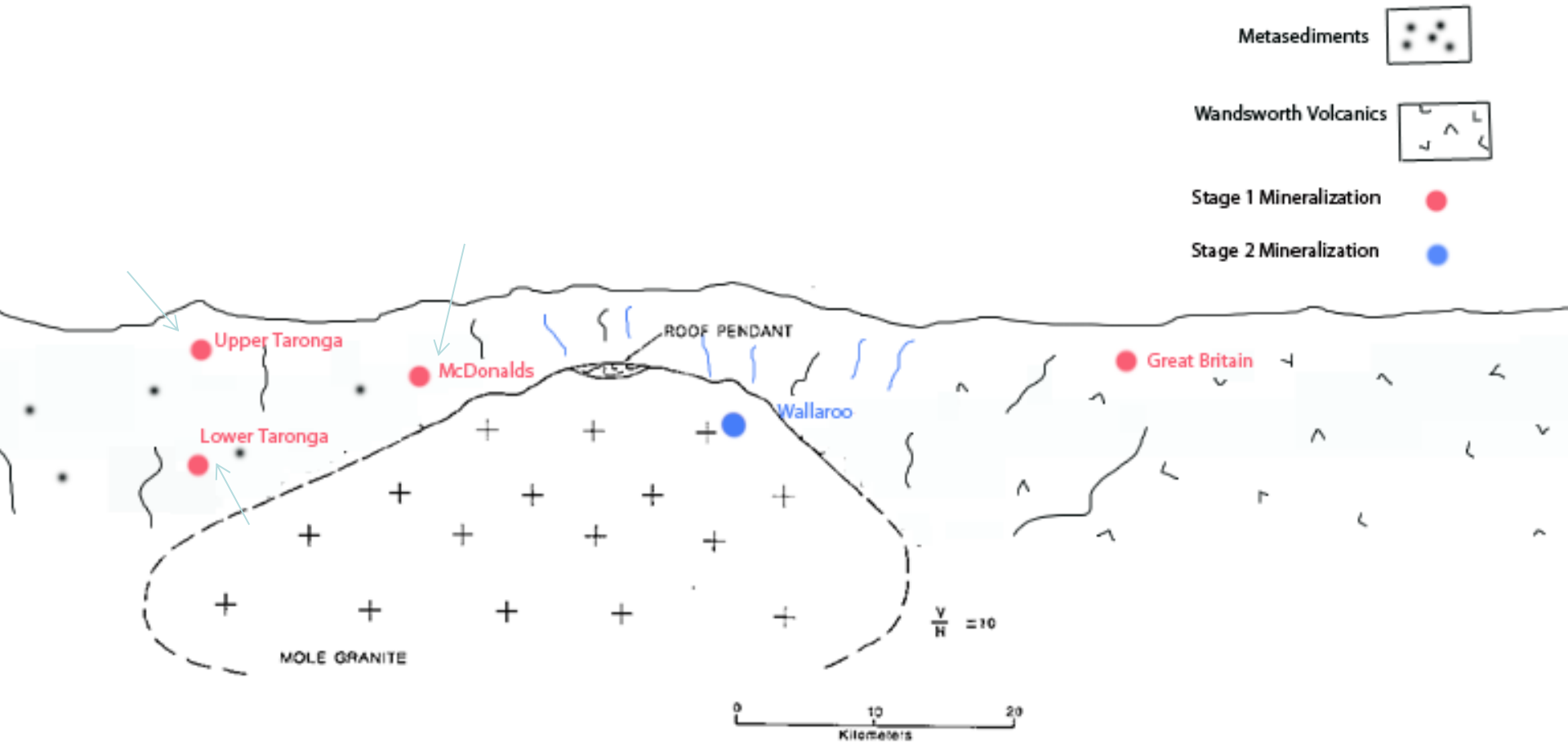


Fractionation$_{(Quartz\text{-}Cassiterite)}$ Equation:

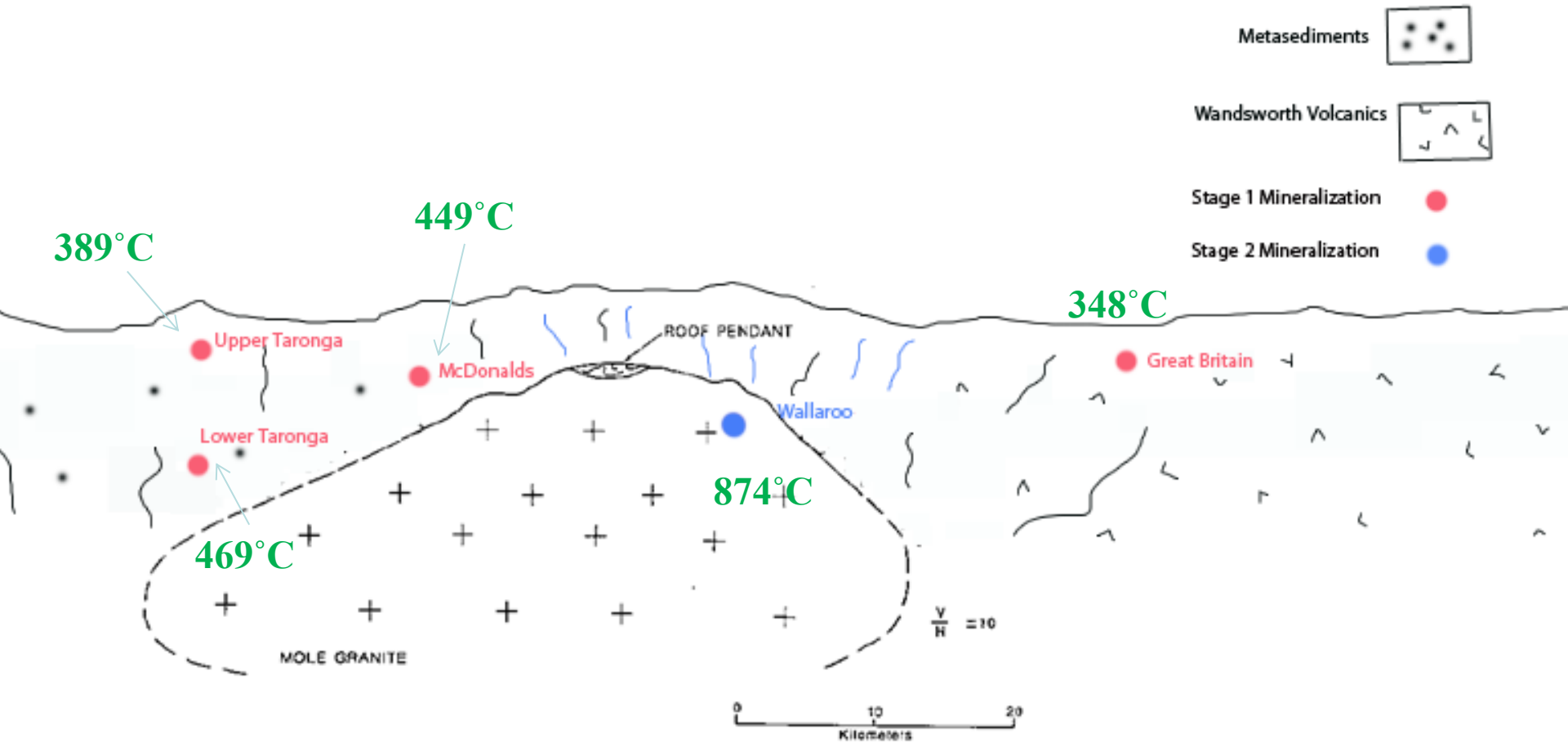
$$10^3 \ln \alpha = A \times 10^6/T^2 + B \times 10^3/T + C$$

Where: $\alpha = \frac{\delta^{18}O_{Quartz}\ (‰)+1000}{\delta^{18}O_{Cassiterite}\ (‰)+1000}$, A = 0.56, B = 5.80, C=-3.04 and T = Temperature (K)

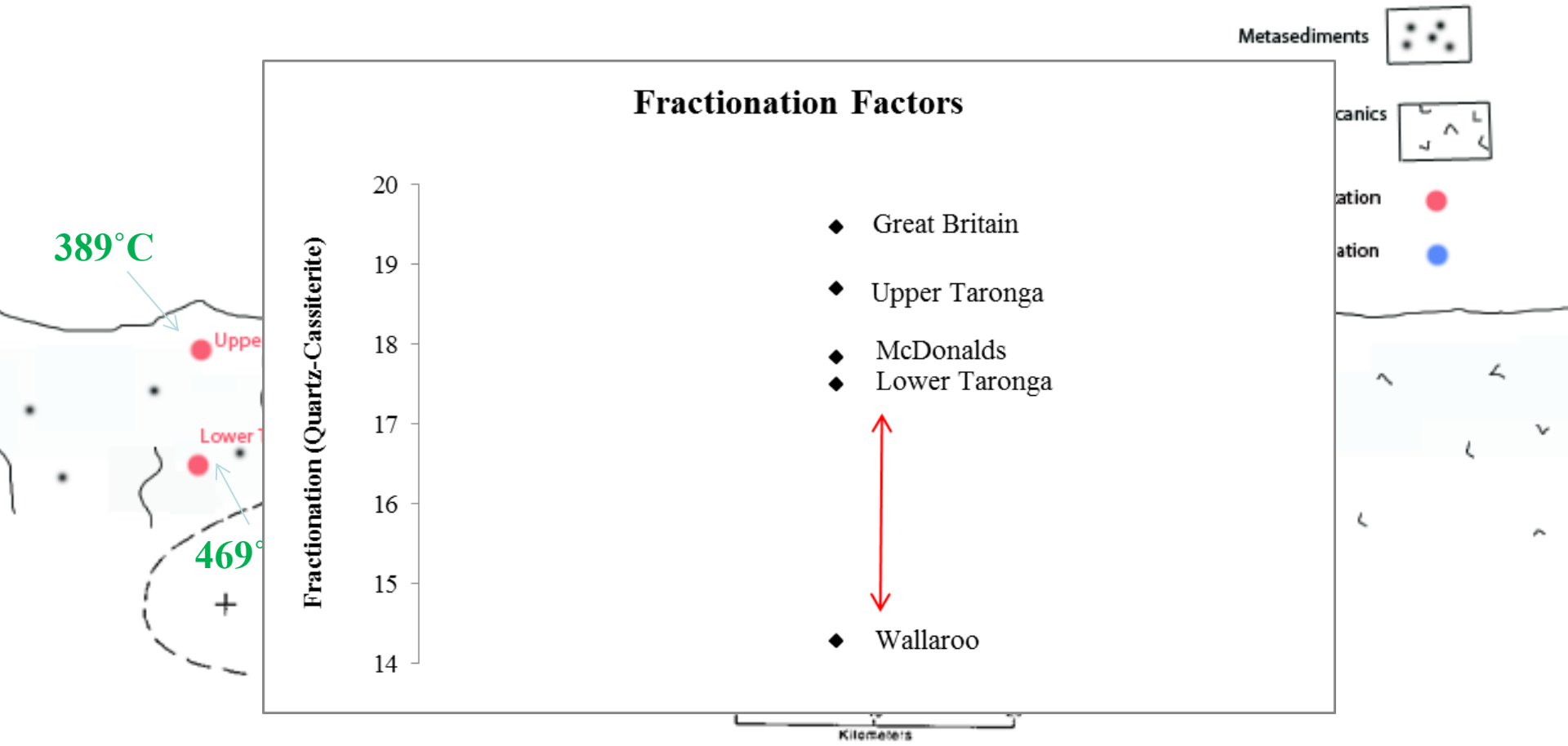
(Zheng, 1991)



Adapted from Kleeman & Plimer, 1991.



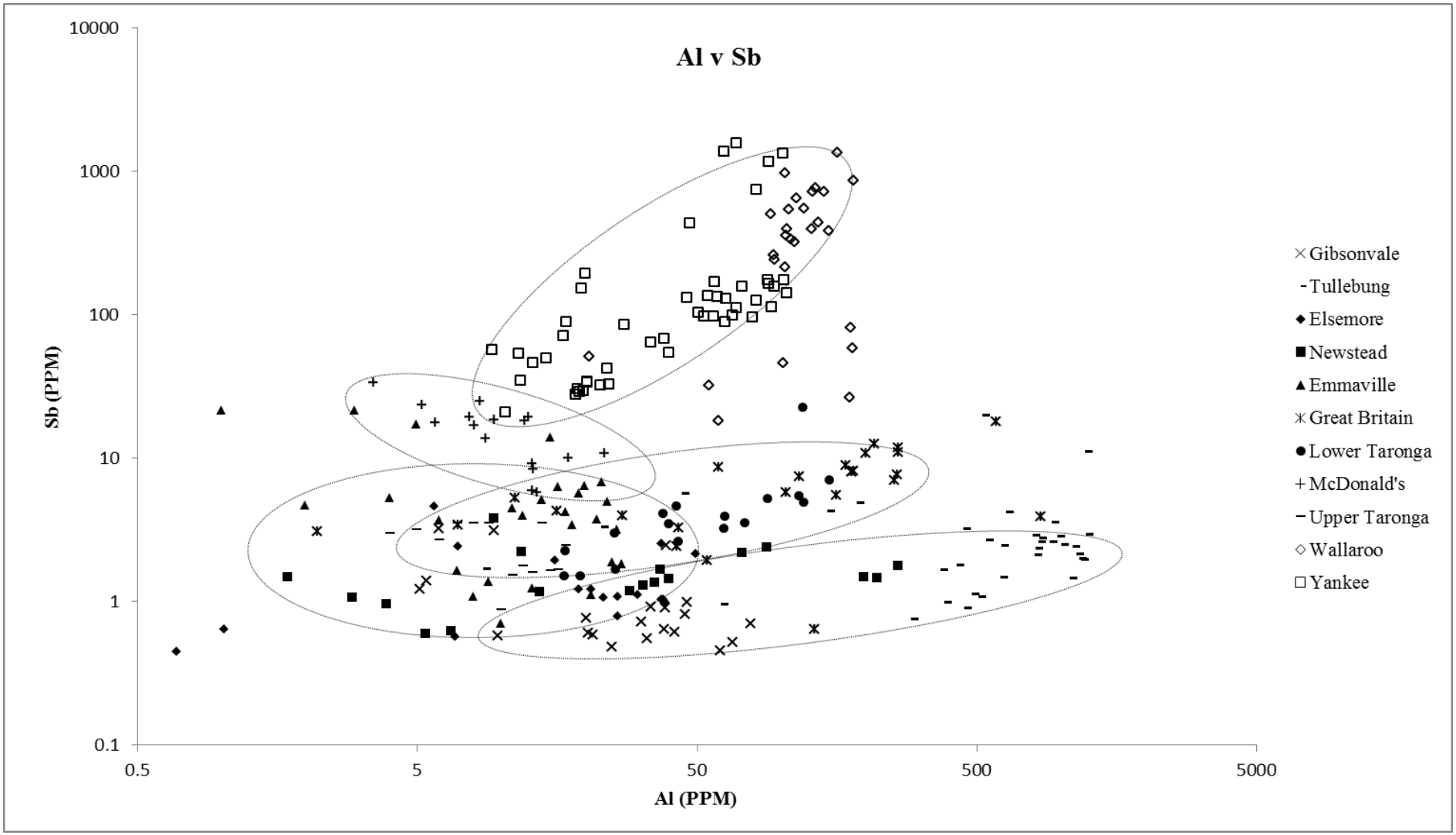
Adapted from Kleeman & Plimer, 1991.

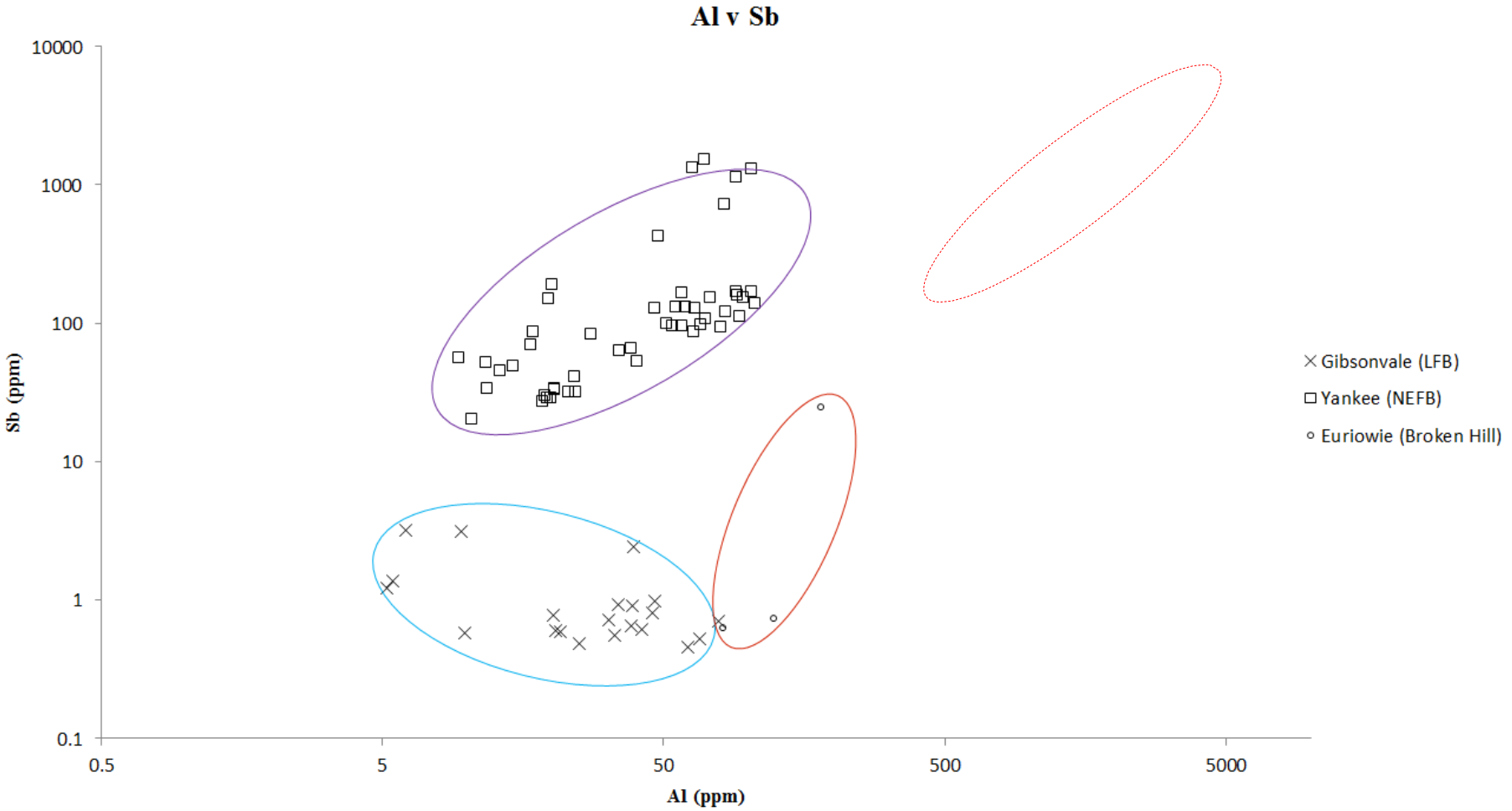


Adapted from Kleeman & Plimer, 1991.

Results: Trace elements

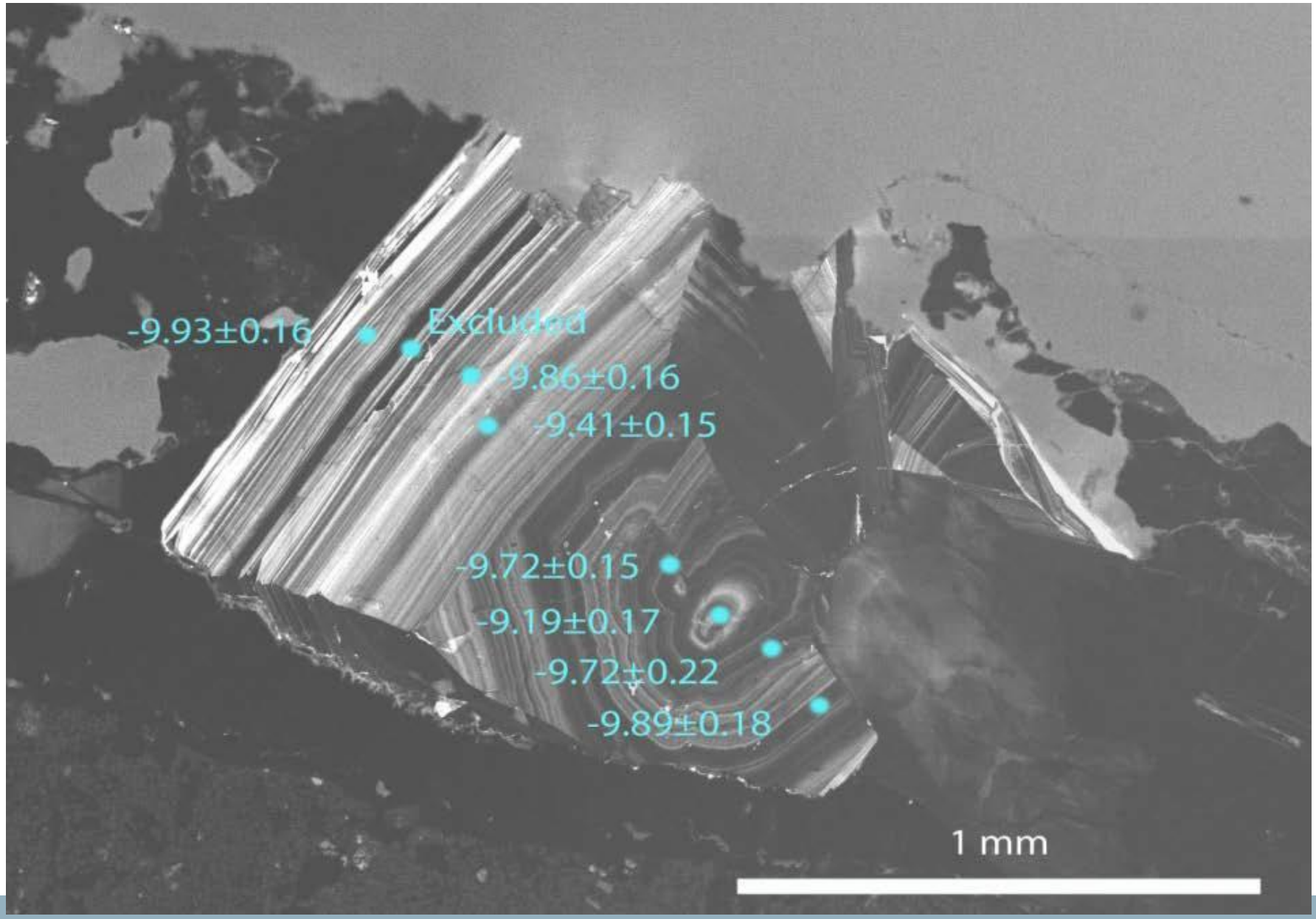
Cassiterite 'Fingerprinting'





Red dashed line is the range of cassiterite from Greenbushes, WA.

Results: intra-granular


-9.93±0.16
Excluded
-9.86±0.16
-9.41±0.15
-9.72±0.15
-9.19±0.17
-9.72±0.22
-9.89±0.18
1 mm

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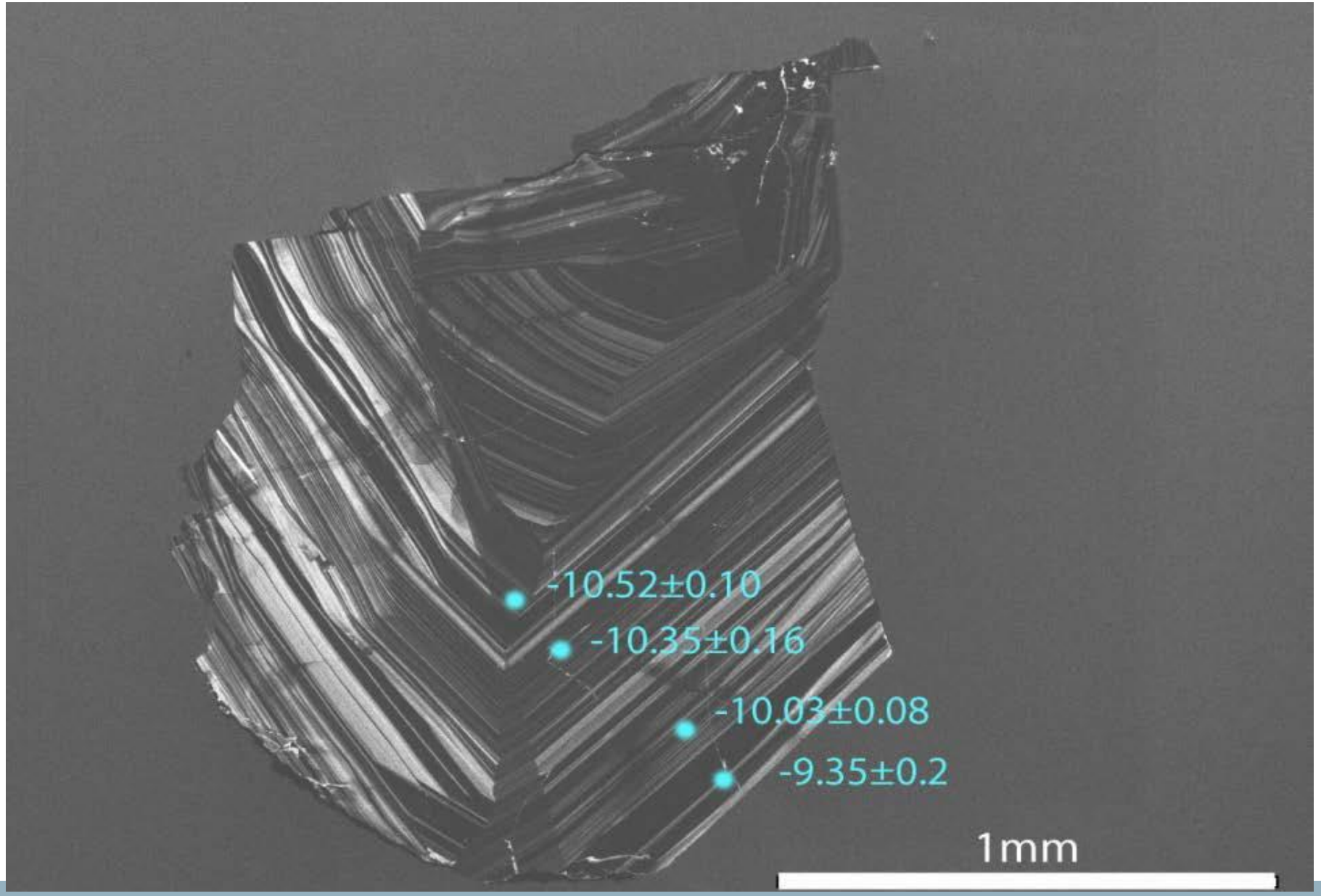
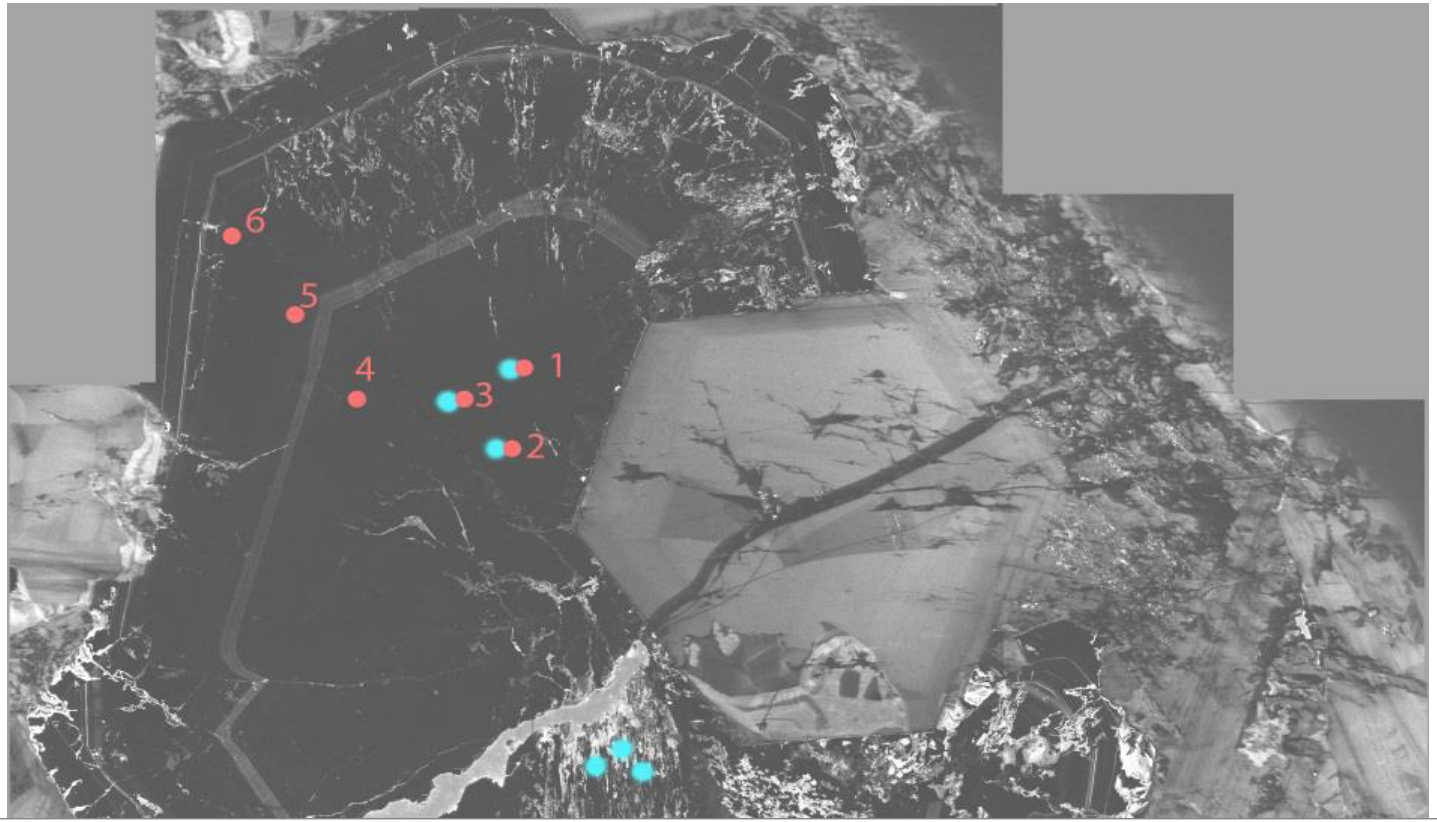
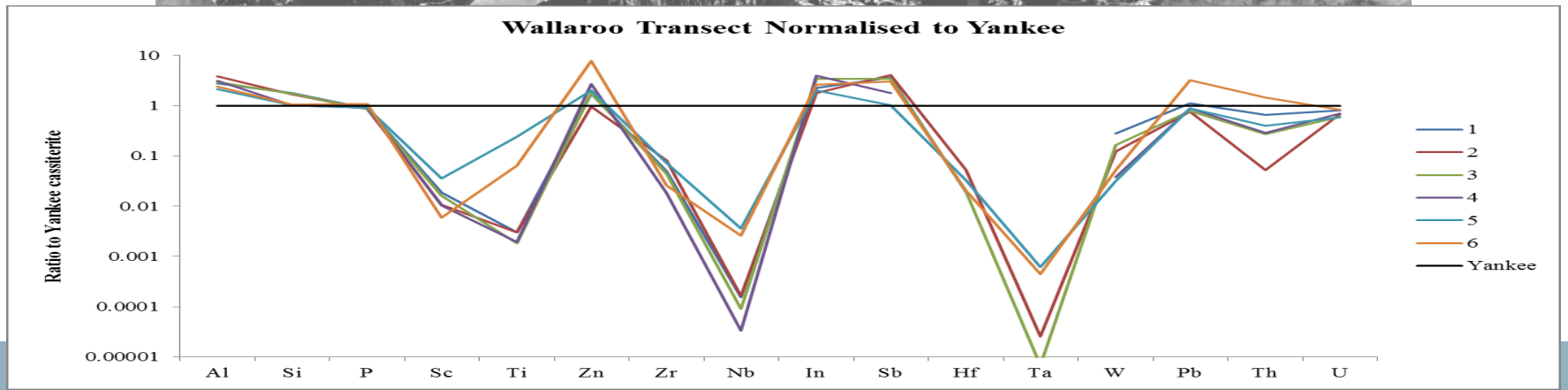



6
5
4
3
1
2


Wallaroo Transect Normalised to Yankee
Ratio to Yankee cassiterite
10
1
0.1
0.01
0.001
0.0001
0.00001
Al
Si
P
Sc
Ti
Zn
Zr
Nb
In
Sb
Hf
Ta
W
Pb
Th
U
1
2
3
4
5
6
Yankee

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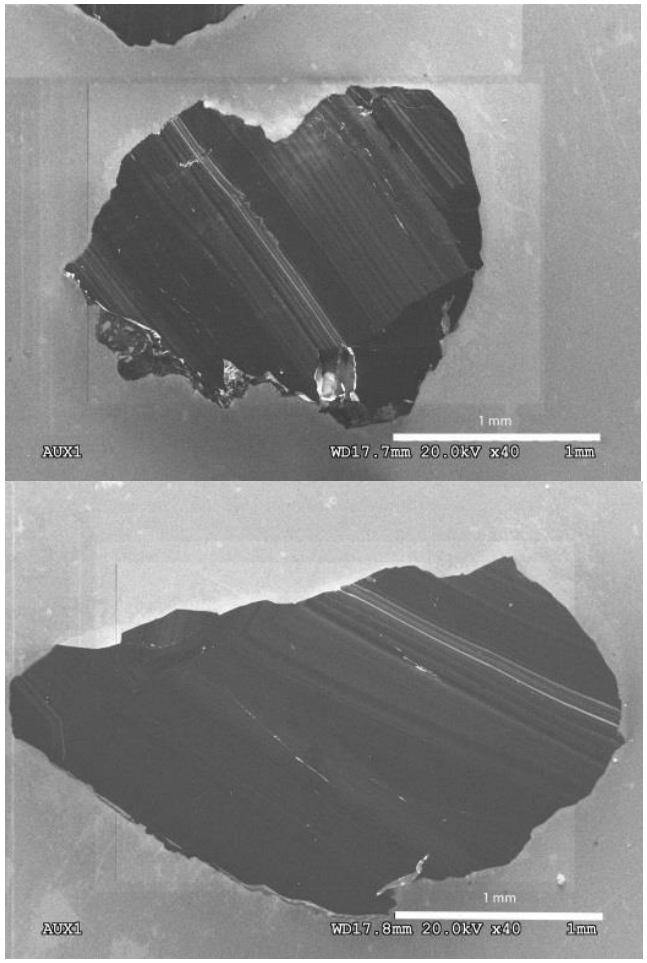
Yankee Cassiterite: a Possible Standard?



Oxygen isotope variation

Location	Min (‰)	Max (‰)	Range (‰)	n (Analyses)	n (Grains)
Yankee	-17.24	-10.36	6.88	21	5
Elsemore	-11.63	-9.17	2.46	45	15
Tullebung	-9.14	-5.62	3.52	38	19
Newstead	-11.13	-8.23	2.90	18	5
Gibsonvale	-13.18	-3.58	9.60	25	7
Emmaville	-13.51	-7.41	6.10	42	12
Wallaroo	-19.50	-16.82	2.68	17	3
Taronga	-11.13	-7.30	3.82	20	5

Trace element variation

	All Yankee Grains			Single Yankee grain		
	Min (ppm)	Max (ppm)	Range (ppm)	Min (ppm)	Max (ppm)	Range (ppm)
n (alalyses)		49			6	
Al	9.23	104.62	95.39	11.56	72.7	61.14
Si	563	2429	1866	1632	2345	713
P	7.51	45.00	37.49	7.60	10.20	2.60
Sc	45	1454	1409	45	729	684
Ti	0.86	4033	4032	126.3	1682	1555
Cu	0.003	0.242	0.24	b.d.l.	b.d.l.	b.d.l.
Zn	0.001	2.680	2.68	0.134	0.444	0.310
Zr	0.0081	131.2	131.2	2.42	49.7	47.28
Nb	0.0231	5325	5325	11.47	3946	3935
Cd	0.017	0.059	0.04	b.d.l.	b.d.l.	b.d.l.
In	2.01	56.3	54.29	3.05	29.22	26.17
Sb	20.74	1555	1534	27.71	156.8	129.1
Hf	b.d.l.	7.87	b.d.l.	0.05	2.22	2.18
Ta	0.002	173.5	173.5	0.012	62.85	62.8
W	5.34	12370	12365	6.58	12370	12363
Pb	0.160	9.72	9.56	0.867	3.52	2.66
Th	0.000	0.379	0.379	0.002	0.002	b.d.l.
U	2.64	568.8	566.2	2.64	80.82	78.18

Conclusions

- Cassiterite can be successfully dated by U/Pb isotopes using the LA-ICP-MS method.
- Oxygen isotopes provide a useful insight into mineralization temperatures in tin deposits.
- Trace element data provides a way to distinguish cassiterites from different formation environments.
- Cassiterite displays complex and useful textures intra-granularly, similar to that of zircon.
- The Yankee cassiterite is too heterogeneous to be a standard, however Elsemore cassiterite appears suitable.